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Alteration of Blood Trace Elements and Electrolytes in Diabetes

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ABSTRACT. Alterations of trace elements and electrolyte levels were investigated in blood of 28 normal subjects and 30 patients with diabetes mellitus. The blood was analyzed for iron, copper, zinc, lead, nickel, chromium, sodium, potassium and calcium. Concentration of chromium, zinc and iron significantly decreased in blood of diabetic patients as compared to normal subjects. Concentrations of nickel and copper decreased also. No significant change was observed in the concentration of lead in normal and diabetic patients. Decreased levels of potassium and calcium and slightly increased level of sodium were observed in diabetic as compared to control subjects. The observed changes in trace elements and electrolyte levels in diabetic patients may have a role in the metabolic disorders that occur in diabetes. The possible role of altered trace elements and electrolytes in the symptomology of diabetes is discussed.

KEYWORDS: Diabetes mellitus, Trace elements, Electrolytes.

Introduction

Trace elements are accepted as essential for human health and have diverse metabolic characteristics and functions. Trace elements participate in tissue, cellular and subcellular functions; these include immuno regulation by both humoral and cellular mechanisms, nerve conduction, muscle contraction, membrane potential regulation, mitochondrial activity and enzyme reactions[1,2,3,4]. Electrolyte homeostasis is made possible by a feed back mechanism involving the participation of the central nervous system, the endocrine system, gastrointestinal tract and kidneys. A primary disturbance in any one electrolyte

may lead to disturbance in another, or indeed in all of others. The concentration of different trace elements in patients with diabetic mellitus were previously investigated and the results were inconclusive. Most of the studies were done by various workers[5,6,7,8] on chromium and zinc in diabetes. Chromium in particular attracted much interest due to its association with diabetes mellitus and due to its impairment with glucose tolerance factor and the prolongation of the action of insulin[9-11]. The present study was designed to investigate the changes in the concentration of trace elements and electrolytes in the symptomology of diabetes.

Materials and Methods

Subjects

30 patients of both sexes with known history of diabetes mellitus were involved in the study they were 38-60 years of age. The patients were under strict dietary control and were on hypoglycemic drug therapy. 28 Age matched normal subjects were involved in study and represented the control group. They were all healthy adults and they had no known history of diabetes mellitus or any other hyperglycemic disorder. None of the women subjects were pregnant or taking oral contraceptives.

Blood Sampling

Blood samples were taken by 10 ml disposable plastic syringes with a low chromium steel needles. Blood samples were immediately transferred to acid washed glass containers containing 200 µ of 10% EDTA. The EDTA solution had been previously tested for the absence of the metal under test[14].

Analytical Methods

Estimation of Trace Elements by Atomic Absorption Spectrophotometry

Standards, samples and blanks for estimation of copper, zinc, lead, nickel and iron were aspirated into a Perkin Elmer 5000 atomic absorption spectrophotometer utilizing a long-path air/acetylene burner and cathode lamp for each metal under investigation. Each sample was read five times at a 1 sec. Integration setting as were the appropriate standards. The concentrations of metals were found by standard addition method. Details of the method, parameters and precautions have been described earlier[12,14].

Estimation of Sodium, Potassium and Calcium by Flame Photometry

Serum sodium, potassium and calcium were estimated by flame photometry [Corning 410] as described earlier[26].

Statistical Analysis

Results are express as mean ± S.D. Statistical significance of the difference between control and test were evaluated by student t-test[13].

Results

Table 1 showed a slight decrease in copper contents of the blood of diabetic patients as compared to normal subjects ($P < 0.1$). A significant decrease in zinc, chromium, iron and nickel in the blood of diabetic patients was observed ($P < 0.001$). No significant difference in the blood lead level was observed in the control or the diabetic patients. A decreased level of potassium and calcium in the blood of diabetics was noted ($P < 0.005$), where as a slight increase ($P < 0.01$) in sodium content of the whole blood of diabetes patients was observed (Table 2).

TABLE 1. Concentration of trace elements in whole blood of normal and diabetic persons.

Metals	Normal	Patient	% Change	P
Copper*	100 ± 39	89.4 ± 40	10	< 0.1
Zinc*	623 ± 91	514.4 ± 89	17	< 0.001
Chromium*	3.1 ± 0.9	1.99 ± 0.8	35	< 0.001
Iron**	48 ± 5	36 ± 8	26	< 0.001
Lead*	42 ± 17	44 ± 16	05	N.S.
Nickel*	50 ± 15	37 ± 14	25	< 0.001

*μ gm / dl ± SD
**m gm / dl ± SD

TABLE 2. Concentration of trace elements in normal and diabetic persons.

Metals	Normal	Patient	% Change	P
Sodium	388.2 ± 55	412.1 ± 52	06	< 0.01
Potassium	195 ± 23	175.4 ± 33	10	< 0.005
Calcium	8.5 ± 1	7.9 ± 1	07	< 0.005

*m gm / dl ± SD

Discussion

Chromium

The results showed significant decrease in chromium level of whole blood (Table 1). Deficiency of chromium or glucose tolerance factor produces an ab-

normal insulin resistance[17,18,19]. Diabetes, which affect glucose metabolism, also affect chromium absorption. It is suggested that patients of diabetes mellitus excrete more chromium than control subjects[15] and the resultant decreased blood levels of chromium as observed in the present study. The low chromium levels in diabetic during the present study have been reported previously[16].

Zinc

In the present study the levels of zinc in blood of diabetic patients decreased. Zinc plays a significant role in the glucose metabolism but in a different ways to the action of chromium. The metal free insulin showed its activity but administration of 1:1 Zn(II)-complex prolonged the action period. The activity of zinc free insulin decreased and is thought to undergo complexation with the trace amount of zinc (II) available *in vivo*[20,21,22]. It has been proposed that the decreased blood zinc level observed during the present study is due to its complex formation with insulin and hence the lack of free insulin enhances the appearance of the symptoms of diabetes that occurred in these patients[22].

Copper, Iron, Lead and Nickel

The concentration of copper decreased in the blood of diabetes patients (Table 1). The decrease of copper may be due to its excretion in urine. Another possible explanation of the low content of copper in blood is the slow transfer of loosely bound copper of ceruloplasmin to the tissues.

The low content of iron in blood of diabetic patients (Table 1) as compared to normal subjects indicates an increase in the chances of anemia. The deficiency may be caused by the inhabition of iron transfer from iron storage protein or increased absorption of iron by the tissues from blood.

Table 1 shows that nickel content of whole blood was also found to be low in diabetic patients as compared to control subjects. The decrease could be due to decrease in plasma carrier protein in a manner similar to that observed in patient with cirrhosis and chronic renal failure[23]. It could also be due to the lowering of iron, since in iron deficiency nickel absorption is also impaired[24]. No changes in the blood lead level were observed in diabetic patients (Table 1).

Sodium, Potassium and Calcium

Table 2 shows an increase in sodium concentration in the serum of diabetics. This increase may be due to reabsorption of sodium. In diabetes with development of hyperglycemia, glucose reabsorption by the distal tubule or collecting duct, increases. In additions tubular cells reabsorb sodium and as a result, whole blood level of sodium is elevated. Another possibility is that the decrease in so-

dium excretion is secondary to the action of insulin. As shown in Table 2 the concentration of serum potassium decreases in diabetic patients. This decrease in potassium may be due to the urinary excretion of potassium or due to the movement of potassium into the cell as described earlier[25]. The calcium content of whole blood of diabetics was found to be slightly lower than normal. This decrease in calcium may be due to its increased excretion rate, during the process of increased reabsorption of glucose by distal tubule or collecting duct. The tubular cells decreased calcium reabsorption by some mechanism.

In conclusion, results shown in the present study suggest that in diabetes the concentration of iron, copper, zinc, nickel, chromium, sodium, potassium and calcium in blood is altered and these alterations may have a definite role in the metabolic disorder and the symptomology of diabetes.

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تغيرات العناصر الشحيحة والإلكتروليتات في دم مرضى السكر

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المستخلص. تمت دراسة تغيرات مستويات العناصر الشحيحة والإليكتروليتات في عينات دم أخذت من ٢٨ شخص عادي و ٣٠ من المصابين بمرض السكر الأطفال . وبعد أن عينت تركيزات كل من الحديد ، والنحاس والزنك والرصاص والنيكل والكروميوم والصوديوم والبوتاسيوم والكالسيوم ، اتضح أن تركيزات الكروميوم والزنك والحديد انخفضت انخفاضًا ملحوظًا في دماء مرضى السكر مقارنة مع الأشخاص العاديين كما أن تركيزات النيكل والرصاص انخفضت أيضًا .

لم يلاحظ تغير يذكر في تركيز الرصاص بين الشخص العادي والمصاب بالسكر . لوحظ أيضًا مستوى منخفض من البوتاسيوم والكالسيوم ومرتفع قليلًا في الصوديوم عند مرضى السكر مقارنة بنظرائهم العاديين . هذه التغيرات في مستوى العناصر الشحيحة والإليكتروليتات ربما تلعب دورًا في اضطرابات الأيض التي تحدث عند مرضى السكر ، وقد ناقشت هذه الدراسة الدور المحتمل لتغيرات العناصر الشحيحة والإليكترولايت في أعراض مرض السكر .